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Cardiff Road
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1. Your reference

P03763GB

2. Patent application number
(The Patent Office will fill in this part)

0224897.9

25 OCT 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

E.T. ENVIRONMENTAL LIMITED
47 CENTRAL AVENUE
WEST MOLSEY
SURREY KT8 2QZ

Patents ADP number *(if you know it)*

If the applicant is a corporate body, give the country/state of its incorporation

GB

8489528002

4. Title of the invention

CLEANING OF AIR

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

LAURENCE SHAW & ASSOCIATES
Metropolitan House, 1 Hagley Road
Edgbaston
Birmingham B16 8TG

Patents ADP number *(if you know it)*

13623001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
GB	0224427.5	21.10.02

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
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Continuation sheets of this form	
Description	14
Claim(s)	3
Abstract	0
Drawing(s)	4 + 4

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Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature LAURENCE SHAW & ASSOCIATES Date Oct 25, 02

12. Name and daytime telephone number of person to contact in the United Kingdom 0121 454 4962

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DUPLICATE

Agent's Ref: P03763GB

Cleaning of Air

The present invention relates to apparatus for and a method of cleaning, for example purifying, air.

It has long been known that harmful agents can be borne by air. These harmful agents may include pathogens, such as micro-organisms, for example mould, bacteria and viruses, allergens, such as pollen as well as dust and other detritus. Many solutions have been proposed to enable effective and efficient cleaning of air to remove such pollutants.

When air is re-circulated in buildings, there is a tendency for such pollutants to become concentrated in the air unless they are adequately removed. In buildings such as hospitals, schools and offices the presence of such pollutants can lead to acute and chronic illnesses and, in the worst cases fatalities. The same problem can arise in vehicles, e.g. aircraft, ships, multiple passenger vehicles; in food processing areas; in mortuaries; and in the cultivation of certain crops such as mushrooms, beansprouts, asparagus, artichokes. The invention is applicable in all these situations.

In closed environments, such as aircraft, motor vehicles and the environments there is often a restraint on what can be installed, space is often at a premium. Other considerations such as the frequency of maintenance and replacing parts also have to be taken into account when installing air cleaning apparatus.

WO-A1-01/87362 discloses air disinfection apparatus having a chamber through which air can flow and an ultraviolet light source which projects light into the chamber to kill bacteria. The apparatus comprises a filter adjacent the inlet to remove larger particulate matter. The UV light source may project into the chamber or may be located in a separate housing, the housing being separated from the chamber by a UV light transparent screen, which is fabricated from quartz or the like.

There are certain problems with the above-identified apparatus. Firstly, when the UV light source is located within the chamber, dirt and other detritus whose passage is not arrested by the filter, adheres to the source. Typically, such detritus is not UV transparent, so reducing the effectiveness of the light radiation. Secondly, when the UV light source is located in a separate housing the amount of UV light which irradiates the chamber is reduced. In this disclosure UV reflective material is present in the housing to reflect at least some of the UV light towards the chamber. Typically, aluminium reflectors are used but these are known to be not ideal. Further, screens fabricated from quartz are relatively expensive.

It has been found that the prior art air cleaners suffer because they either ineffectively irradiate the space through which the polluted air is to pass, or the UV light source becomes adhered with detritus. A further problem sometimes found is that the air duct may have to be shut down when replacing the UV light source(s).

Accordingly, it is an object of this invention to reduce and ideally eliminate the problems found with prior art air cleaners. It is a particular object to provide apparatus which can be fit in a duct, or retro-fit to an existing duct or used in a

portable system. Other advantages of this invention will become apparent from the following.

A first aspect of the invention provides apparatus for cleaning air, the apparatus comprising a chamber having an inlet and an outlet for passage of air therethrough a plurality of UV light sources to irradiate the interior of the chamber, including one or more shield members about each light source to reduce deposition of air-borne detritus on the UV light source.

In another aspect, the invention provides apparatus for cleaning air, the apparatus comprising a chamber having an inlet and an outlet for the passage of air therethrough, a plurality of U V light sources to irradiate the passing air, wherein the power supply to the light sources is individually controlled.

In yet another aspect the invention provides apparatus for cleaning air, the apparatus comprising a chamber having an inlet and an outlet for the passage of air therethrough, a plurality of U V light sources to irradiate the passing air, wherein the mean level of radiation is about 10 milliwatts/cm^2.

In yet another aspect the invention provides apparatus for cleaning air, the apparatus comprising a chamber having an inlet and an outlet for the passage of air therethrough, a plurality of U V light sources to irradiate the passing air wherein a heat sink is associated with each light source.

Preferably each shield member is made of a UV transparent material.

Preferably the UV transparent material is made or quartz or fused silica.

Preferably each shield member is a tube disposed about a cylindrical lamp which is the UV light source.

Preferably each shield member is detachable from the light source for cleaning purposes.

Preferably each light source is a lamp of non-circular cross sectional shape.

Preferably a heat sink is associated with each light source.

Preferably, the UV light sources are UV lamps, emitting light in the UV-C band (typically 254 nm). Suitable UV lamps are elongate tubes, it has been found that for good effect the lamps should have a non-circular cross-sectional shape, say oval with flats. This increases the effective area of radiation. Preferably the lamps are arranged in banks, say each of four lamps. Preferably the mean level of radiation is about 10 milliwatts, mean level.

The UV transparent shield member is preferably tubular. The member may be formed from quartz or another UV transparent material such as fused silica.

The chamber may comprise one or more walls which comprise a UV reflective surface, such as quartz mirrors, or polished aluminium or the like. One or more walls comprising a UV reflective surface may be shaped to present a concave surface to the flowing air, say to form a parabolic or other reflector.

In one embodiment, the UV light sources extend across the chamber, preferably perpendicular to the intended flow of air, each light source being separated from the chamber by a UV transparent shield member. In other embodiments the light sources are at different inclinations.

In another embodiment the chamber is tubular and the UV transparent shield member is tubular and co-axially mounted within the chamber to define a tubular air flow path, the UV light sources being mounted in the annular space between the chamber and the transparent shield member.

The apparatus may also include first filter means situated across the inlet and, preferably second filter means situated across the outlet. The first filter means may comprise an electrostatic filter element and the second filter means may comprise a HEPA filter element. Extra filter elements may be present at the inlet and/or the outlet.

Preferably one or both of the electrostatic and HEPA filter elements are fabricated from a UV transmitting material. The second filter means may comprise a frame, preferably a combustible frame, such as one fabricated from wood, a derivative of wood or the like.

A component made of a material which releases hydroxyl ions known to be detrimental to pathogens may be present. Such a material may be a metal oxide such as titanium dioxide.

The apparatus may further comprise turbulence inducing means, arranged to induce turbulence in air flowing through the chamber. The turbulence inducing

means may comprise a fixed blade fan or baffles located downstream or upstream of the inlet. The UV transparent shield member may comprise the turbulence inducing means.

A second aspect of the invention provides an air cleaning unit comprising a housing with an inlet and an outlet and having mounted therebetween apparatus comprising a chamber having an inlet and an outlet, a passageway between the inlet and the outlet for the passage of air, a plurality of UV light sources to irradiate the chamber, one or more UV transparent shield members separating each light source from the chamber to prevent adhesion of air-borne detritus to the UV light sources and air movement means located in the housing, operable to cause air to flow into the housing inlet through the chamber and out of the housing outlet.

There is further provided, by a third aspect of the invention, a method of cleaning air comprising moving air through air cleaning apparatus, the apparatus comprising a plurality of UV light sources the surface of each being shielded from the air flow by a UV transparent shield member, irradiating the air with UV light as it passes through the apparatus and expelling cleaned air.

The invention will now be described, by way of example only, and with reference to the accompanying Figures in which:

Figure 1 is a perspective view of a first embodiment of air cleaning apparatus according to the invention;

Figure 2A is an elevation of a second embodiment of air cleaning apparatus according to the invention;

Figure 2B is a view along line A-A' of Figure 2A;

Figure 3A is an elevation of a variation of the second embodiment of air cleaning apparatus according to the invention;

Figure 3B is a view along line B-B' of Figure 3A;

Figure 4A is a side elevation of a unit according to the invention;

Figure 4B is a front elevation of the unit of Figure 4A; and

Figure 4C is a plan view of the unit of Figure 4.

Referring to Figure 1, there is shown air cleaning apparatus 1 having a chamber 2 in which is located a series of quartz sleeves 3 (13 being shown, but the number may be raised, and range from say 8 in two banks each of 4 lamps). A UV-C lamp 4 is located within each sleeve 3. At one end of the chamber 2 there is mounted an electrostatic filter 5 across the inlet to the chamber 2. Below the filter 5 is a UV screen 9. The filter is arranged to give particles a static charge. At the other end of the chamber 2, across the outlet thereof, there is mounted a HEPA filter 6.

The lamps are arranged to emit light in the UV-C band of about 254 nm. The output is about 10 milliamps/cm^2 mean level, and a heat sink is present to keep the temperature at about 100^{0}C.

Two opposed walls 20, 21 of the chamber 2 have a concave inner surface, the other two walls 22, 23 being planar. Walls 20, 21 are formed from, have applied thereto, or are coated with aluminium, which is polished or shiny to enhance the UV reflectivity of the walls 20, 21. The planar side walls are similarly treated.

In use, air is drawn or pushed through the apparatus in the direction of arrow X by fan means (not shown). Thus, air is pre-filtered by the electrostatic filter 5 to remove relatively large particulate material and enters the chamber 2 where it is

irradiated by the UV-C lamps 4. It will be appreciated that the UV-C radiation is emitted through 360° and, because of the number and arrangement of the lamps, maximum irradiation of the incoming air is ensured. The UV-C light is also reflected from the walls 20, 21, 22, 23 to ensure complete irradiation of the space defined by the walls 20, 21, 22, 23. The concave surfaces of walls 20, 21 act as parabolic reflectors to the UV-C radiation. The radiation cannot escape from the chamber, so reducing the risk of injury to an operator. As the air is drawn or pushed through the chamber the transported viruses, mould and bacteria are killed or rendered inert by the actinic radiation.

The electrostatic filter may be formed of a UV transmissible material. It may also have one or both of its major surfaces coated with an anti-microbial or biostat substance.

After passing through the UV irradiation zone, the air is finely filtered by the HEPA filter 6. Any organisms which have not been affected by the UV-C radiation, are trapped on or in the HEPA filter 6. The HEPA filter element 61 is preferably made from a UV transmissible material such as glass fibres. Therefore, any trapped bacteria, mould or virus undergoes further irradiation, ensuring that it is rendered non-viable. The HEPA filter element 61 may be held in place by a frame 62. Preferably, the frame 62 is fabricated from a combustible material, such as wood. Once the nominal lifetime of the filter 6 has elapsed, the whole filter 6 may be removed and incinerated. The frame 62 makes it easy for an operator to remove and replace the filter 6. Another filter may be present, e.g. of carbon particles.

During operation of lamps 4, there is a tendency for a static field to build up, which usually attracts dust and dirt particles. These fall on the sleeves instead of on

the lamps 4. The sleeves 3 also ensure that a degree of turbulence is induced into the air flowing through the chamber 2.

It will be appreciated that to change a lamp 4 during routine maintenance it is unnecessary to turn off the power to all of the lamps 4. The emissive part of each lamp 4 is within the chamber 2, thus an operator may simply disconnect the power supply to the lamp 4 which is to be changed and slide that lamp 4 out of its respective sleeve 3. The procedure is reversed to install a new lamp. This is advantageous because there is reduced down-time for the apparatus and during lamp replacement there is a reduced risk of exposure of the operator to UV-C radiation.

During routine maintenance of the apparatus 1, the sleeves 3 may require cleaning. To do so it is necessary to cut off power to the unit 1. The sleeves 3 can then simply be removed and wiped clean.

It is a feature of the invention that when the apparatus is switched off the lamps are energised for about 5 minutes and continue to operate after the fan is switched off. This reduces the risk of injury to the operator. Dual safety circuits and UV-C protected inspection windows are present to confirm that lamps are switched off.

Figures 2A and 2B show a second embodiment of air cleaning apparatus 101 having a chamber 102 mounted within which elongate UV-C lamps 104 (8 being shown), are circumferentially spaced about the inner periphery of the chamber 102, with their axes parallel to that of the chamber 102. A quartz sleeve 103 is mounted co-axially within the chamber 102, the lights being located between the sleeve 103

and the wall of the chamber 102. If it is desired that a greater intensity of UV light is to be directed to the centre of the chamber 102, a quartz focussing lens 110 may be located adjacent each lamp 104.

An electrostatic filter 105 is mounted across the inlet to the chamber 102. At the other end of the chamber 102, a HEPA 106 extends across the outlet.

The internal surface 123 of the wall of the chamber 102 is formed from, is coated with, or has placed thereupon aluminium, which is polished.

Mounted upstream of the electrostatic filter 105 is a fixed blade fan 130. The fan 130 induces turbulence in any air which flows thereby.

In use, air is drawn or pushed through the apparatus 101 in the direction of arrow Y by fan means (not shown). Thus, air is pre-filtered by the electrostatic filter 105 to remove relatively large particulate material. The air passes by the fan 130 which induces turbulence in the air flow, which air then enters the chamber 102 where it is irradiated by the UV-C lamps 104. The UV-C light is also reflected from the walls 123 to ensure complete irradiation of the space defined by the sleeve 103. As the air is drawn or pushed through the chamber 102 viruses, mould and bacteria are killed or rendered inert by the actinic radiation.

The electrostatic filter 105 may be formed of a UV transmissible material such as glass fibres. It may also have one or both of its major surfaces coated with an anti-microbial biostatic coating.

After passing through the UV irradiation zone, the air is finely filtered by the HEPA filter 106. Any viable mould, bacteria or viruses which have not been killed by the UV-C radiation, will be trapped on or in the HEPA filter 106. The HEPA filter element 161 is preferably made from a UV transmissible material such as glass fibres. Therefore, any trapped bacteria, mould or virus undergoes further irradiation, ensuring that it is rendered non-viable. The HEPA filter element 161 may be held in place by a frame 162. Preferably, the frame 162 is fabricated from a combustible material, such as wood. Once the nominal lifetime of the filter 106 has elapsed, the whole filter 106 may be removed and incinerated. The frame 162 makes it easy for an operator to remove and replace the filter 106, and aids in the incineration process.

During operation of lamps 104, there is a tendency for a static field to build up, which usually attracts dust and dirt particles. The sleeve 103 prevents the build up of dust or other detritus on the lamps 104.

Figures 3A and 3B show a variation of the apparatus of Figures 2A and 2B, wherein identical components are indicated by the same numerals with the addition of a prime (').

The apparatus 101' has all of the components previously described with the exception of the lamps 104. In the apparatus 101', a series of toroidal or omega shaped lamps 204 (8 shown) are located along the major axis of the chamber 102' in the space defined between the quartz sleeve 103' and the inner wall of the chamber 102'. As will be appreciated, operation of apparatus 101' accords with that of 101.

The apparatus 1, 101, 101' may be used to clean air in a fixed system, such as those used in buildings, vehicles and the like, wherein air from, say, a room is exhausted via ducting which is connected to the inlet of the apparatus 1, 101, 101'. The so-cleaned air is then returned to the, say, room either directly or via a further air conditioning plant, for example a heat exchanger to warm or cool the air.

Several air-cleaning apparatus 1, 101, 101' may be connected in parallel so that cleaning or routine maintenance of one may be carried out whilst the others are operating.

The apparatus 1, 101, 101' may also be used in a portable air-cleaning unit 200, as shown in Figures 4A, 4B and 4C. The unit 200 has a housing 201 in which is located the air cleaning apparatus 1, 101, 101' according to the invention. Fan means 210 is located within the housing 201 adjacent the outlet of the apparatus 1, 101, 101' to draw dirty or un-purified air through the apparatus 1, 101, 101' and expel cleaned air in the direction of arrow Z via a grille or screen 202.

A power supply will be provided to power the various components of the unit 200. A logic circuit device may be present to detect dirty filters, component failure, power interruption, and the like and to cause a fail safe shut down.

The unit 200 may have a baffle 207 mounted within the housing 201 adjacent the inlet of the apparatus 1, 101, 101' to prevent any UV-C radiation form exiting the housing 201.

Preferably, the unit 200 will be provided with sensors to monitor the pressure drop across the filters of apparatus 1, 101, 101'. As the pressure drop increases it is

evidence that a filter element is becoming occluded with matter. The signals from the sensors can be compared with pre-calibrated readings to enable a micro-processor or other comparitor to activate a warning signal when the filter or filters require replacement. The unit may also have sensors to monitor the output of the lamps to activate a warning signal upon failure of the lamps. A lamp-lifetime countdown timer may also be provided to monitor the time of use of the lamps. An access panel 205, which affords access to the apparatus 1, 101, 101' may be interlocked to the energy source for the lamps. Thus, opening the panel will cause the energy supply to the lamps to be interrupted.

The unit 200 may be provided with fan means to push air through the apparatus 1, 101, 101'. Any suitable device may be used , such as a fan or other device known to be useful in moving air.

The apparatus 101, 101' need not have a fixed blade fan 130, 130'. Other baffle arrangements may be provided or turbulence inducing means may be omitted.

The apparatus of the invention 1, 101, 101' is space-efficient, effective in destroying potential pathogens and in cleaning air. The presence of a plurality of light sources, each being shielded from the direct flow of the air confers many advantages. The apparatus may be retro-fit into existing air-cleaning apparatus.

The invention is not limited to the embodiments shown. Baffles may be present to prevent UV radiation leakage such as a UV screen at the inlet and the outlet. A carbon filter may also be present at the outlet. Devices to generate ozone, electronic controllers may be present to monitor the temperature of the lamps and intensity.

CLAIMS

1. Apparatus for cleaning air, the apparatus comprising a chamber having an inlet and an outlet for the passage of air therethrough, a plurality of U V light sources to irradiate the passing air and including a shield member about each light source to reduce deposition of air borne detritus on the UV light source.

2. Apparatus according to Claim 1, wherein each shield member is made of a UV transparent material.

3. Apparatus according to Claim 2, wherein the UV transparent material is made or quartz or fused silica.

4. Apparatus according to Claim 1 or 2, wherein each shield member is a tube disposed about a cylindrical lamp which the UV light source.

5. Apparatus according to Claim 4, wherein each shield member is detachable from the light source for cleaning purposes.

6. Apparatus according to any preceding Claim, wherein the power supply to the light sources is individually controlled.

7. Apparatus according to any preceding Claim, wherein each light source is a lamp of non-circular cross sectional shape.

8. Apparatus according to any preceding Claim, wherein a heat sink is associated with each light source.

9. Apparatus according to any preceding Claim, wherein each light source is arranged to emit light at about 254 nm.

10. Apparatus according to any preceding Claim, wherein the mean level of radiation is about 10 milliwatts/cm^2.

11. Apparatus according to any preceding Claim, arranged so that the light sources continue to operate for a short period after the air flow is switched off.

12. Apparatus according to any preceding Claim, wherein a UV screen is present at the outlet.

13. Apparatus for cleaning air, the apparatus comprising a chamber having an inlet and an outlet for the passage of air therethrough, a plurality of UV light sources to irradiate the passing air, wherein the power supply to each of the light sources is individually controlled.

14. Apparatus for cleaning air, the apparatus comprising a chamber having an inlet and an outlet for the passage of air therethrough, a plurality of UV light sources to irradiate the passing air, wherein the mean level of radiation is about 10 milliwatts/cm^2.

15. Apparatus for cleaning air, the apparatus comprising a chamber having an inlet and an outlet for the passage of air, wherein a heat sink is associated with each light source.

5

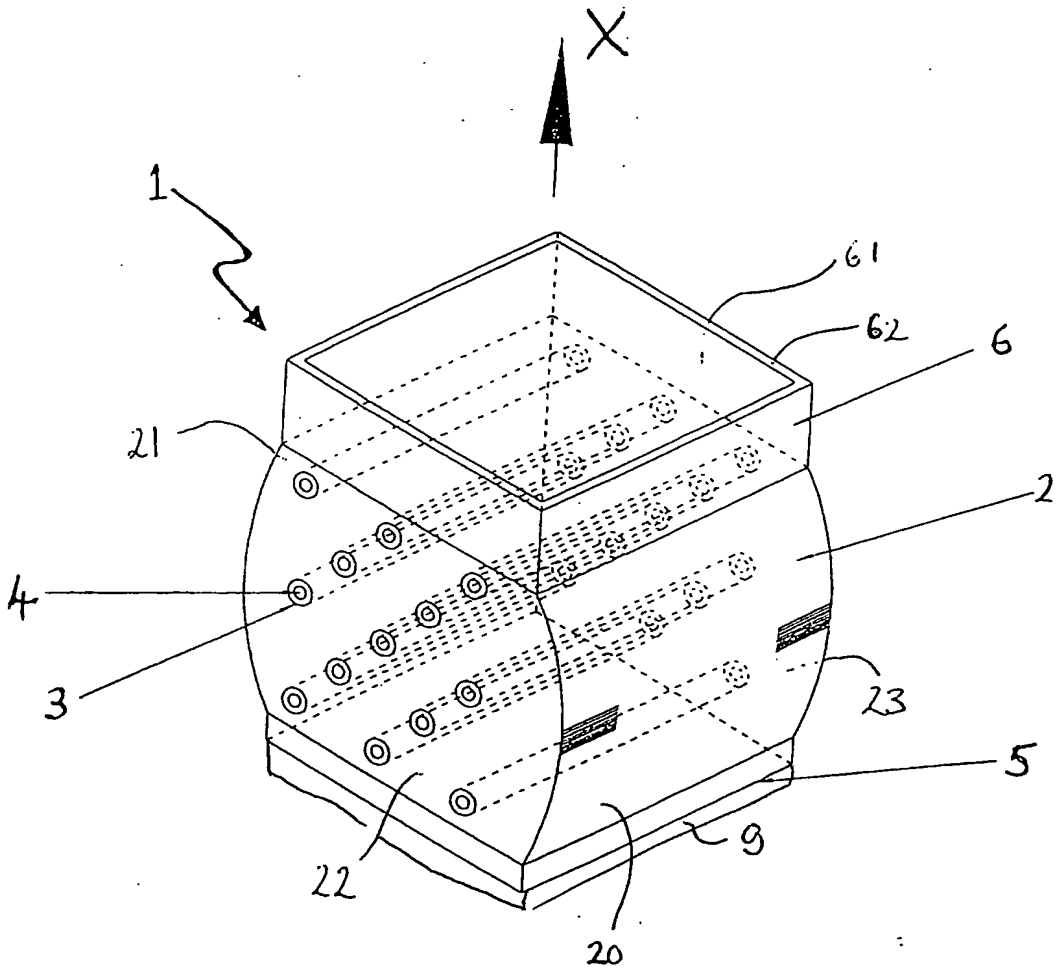

Figure 1

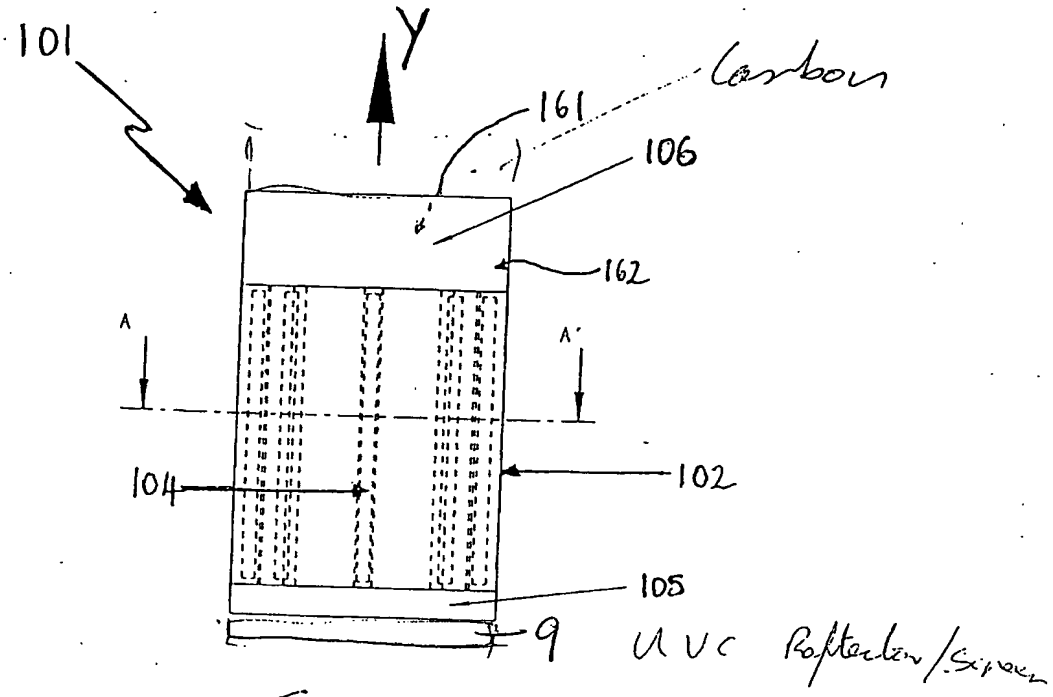

FIGURE 2A

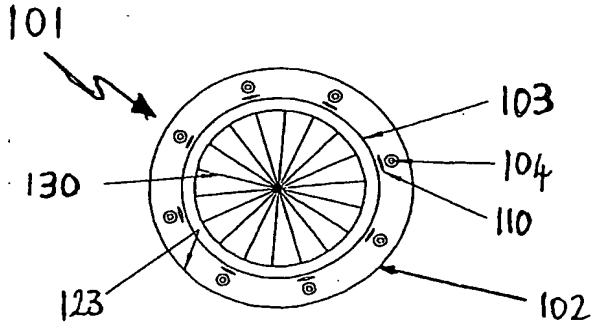

FIGURE 2B

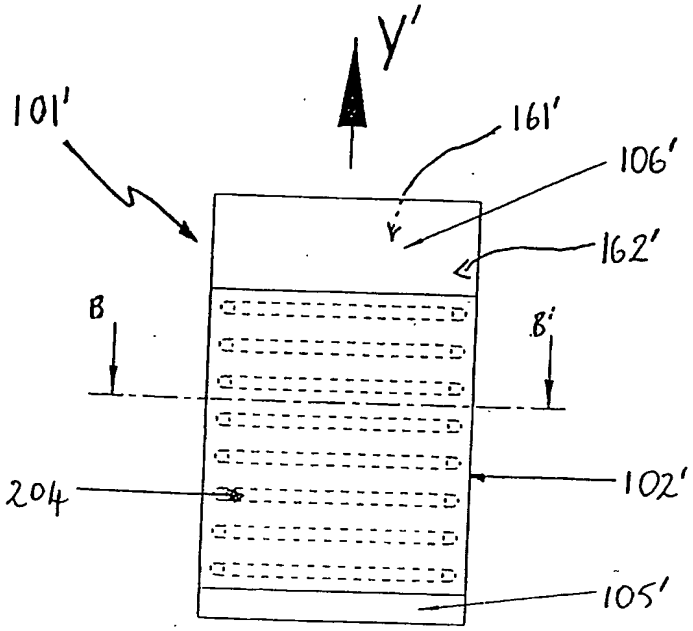

FIGURE 3A

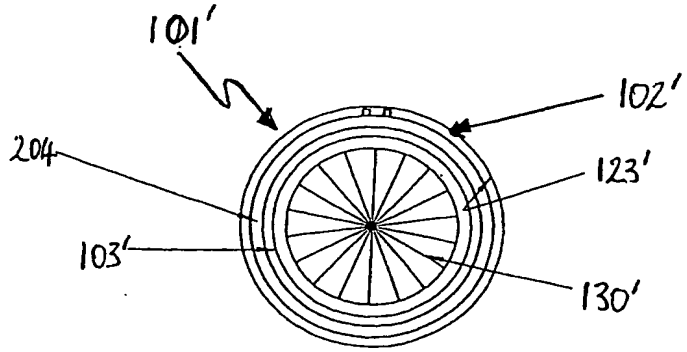

FIGURE 3B

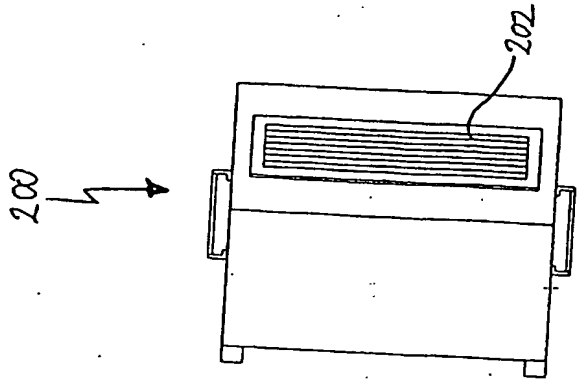

Figure 4C

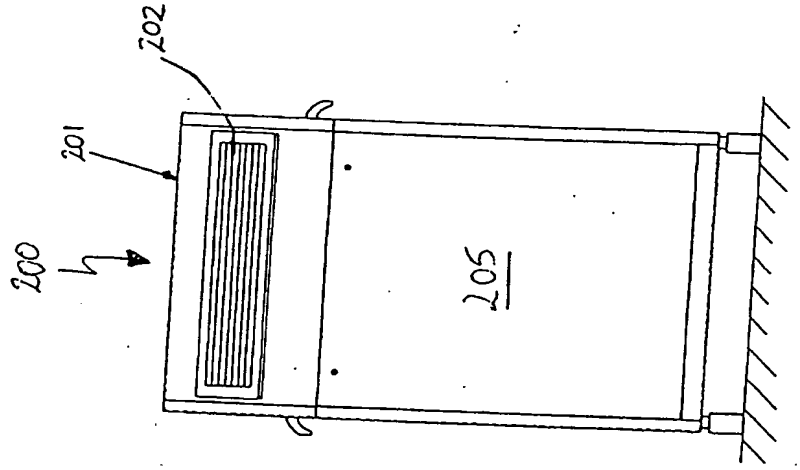

Figure 4B

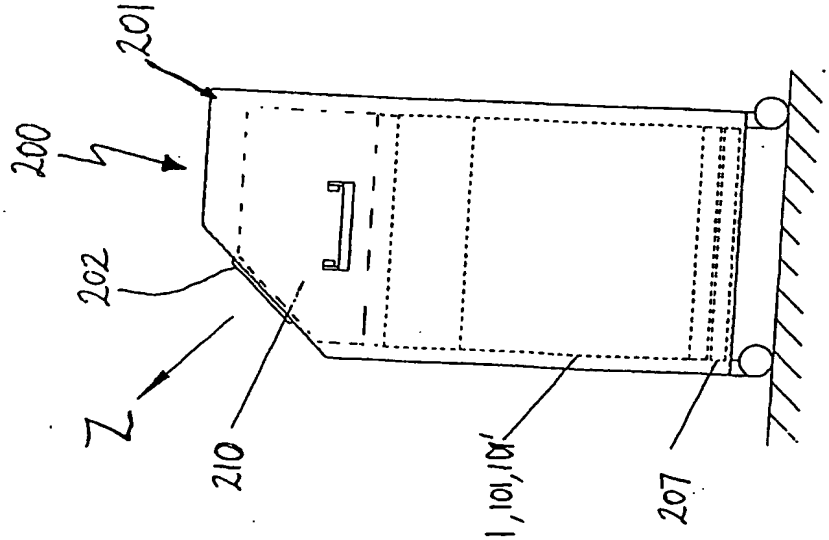

Figure 4A

PCT Application
GB0304540